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EPA TMDL Case Study

Truckee River, Nevada

Key Feature:	TMDLs protecting instream beneficial uses and the quality of a downstream lake
Project Name:	Truckee River
Location:	EPA Region IX/East-central California, Western Nevada
Scope/Size:	River, watershed 2,300 mi^2
Land Type:	Ecoregion 5 (high mountains) and Ecoregion 13 (plains with low to high mountains) (USEPA, 1989)
Type of Activity:	Agriculture, urban
Pollutants:	Nitrogen, phosphorus, total dissolved solids
TMDL Development:	PS, NPS
Data Sources:	State, Truckee Meadows Wastewater Reclamation Facility, Desert Research Institute, cities of Reno and Sparks
Data Mechanisms:	DSSAM III
Monitoring Plan:	Yes
Control Measures:	Riparian corridor protection, irrigation modification, stormwater permitting, public education, agricultural BMPs, wetlands treatment systems

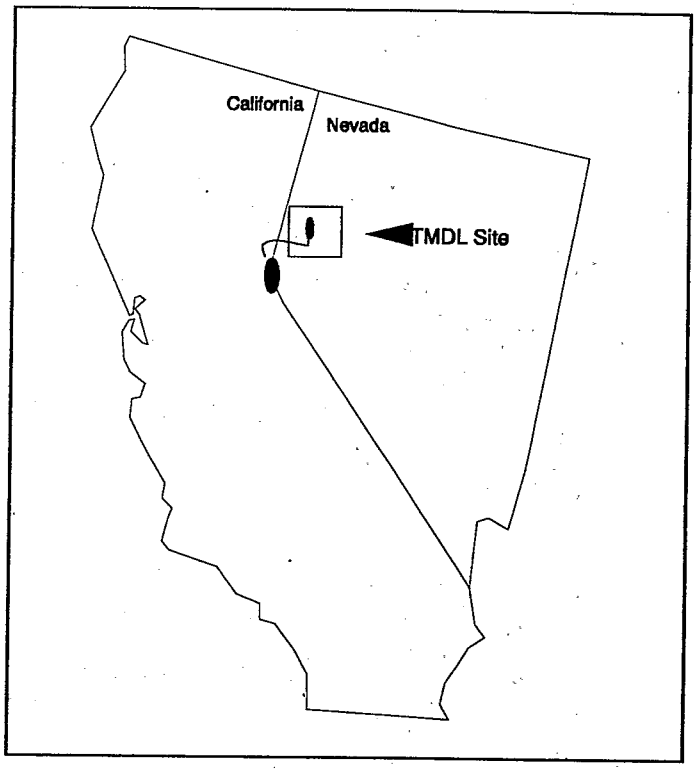

FIGURE 1. Location of Truckee River & Pyramid Lake

Summary: The Truckee River flows from Lake Tahoe, California, into Nevada's Northern Basin, terminating at Pyramid Lake (Figure 1). In recent years, heavy growths of aquatic weeds and benthic algae, caused by high nutrient loads and low flows, have plagued the river. Plant respiration and decaying biomass have decreased dissolved oxygen (DO) levels in the river. The low levels of DO have, in turn, impaired the river's ability to support populations of Lahontan cutthroat trout, a threatened species, and cui-ui (kwee-wee), a national endangered species.

In response to these problems, the Nevada Division of Environmental Protection (NDEP) developed the *Truckee River Strategy*, a plan to coordinate the activities of agencies involved in restoring the quality of the Truckee River and Pyramid Lake. The strategy includes timetables for numerous nonpoint source control projects, such as stormwater permitting, wetlands treatment systems, pasture improvements, riparian restoration, and landowner education. Also, as part of the strategy, NDEP used DSSAM III, a water quality model, to develop nitrogen, phosphorus, and total dissolved solids TMDLs for the Truckee at Lockwood, Nevada. The model is designed for systems like the Truckee, in which benthic processes play a major role in determining water quality. The TMDLs include load allocations for nonpoint and background sources and one wasteload allocation for the major point source discharger in the basin, the Truckee Meadows Wastewater Reclamation Facility. EPA Region IX approved the Truckee River TMDLs in March, 1994.

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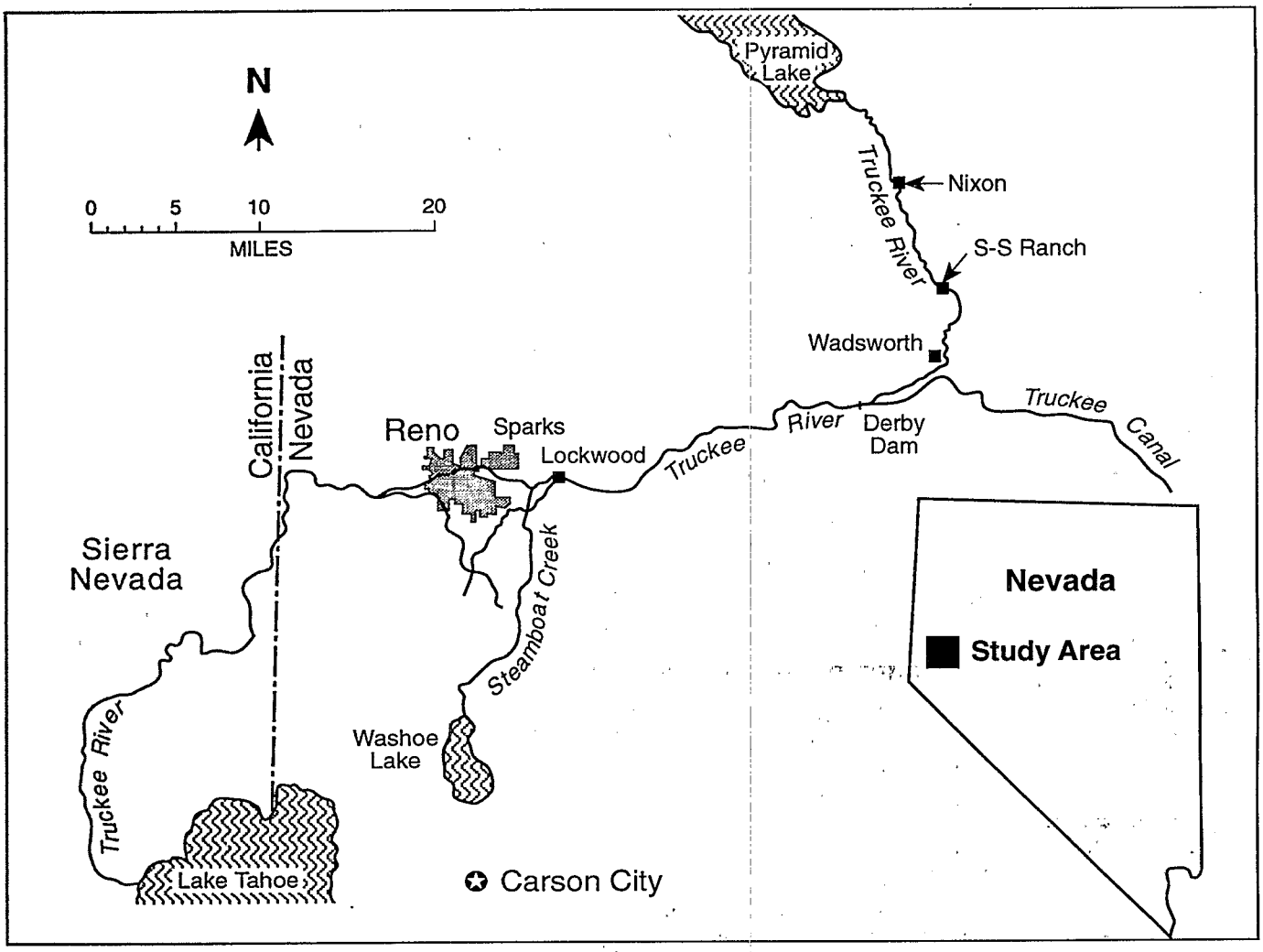

FIGURE 2. The Truckee River-Pyramid Lake region

BACKGROUND

The Resource

The Truckee River originates on the California side of Lake Tahoe and flows northeastward for more than 70 miles before terminating at Pyramid Lake in Nevada (Figure 2). The Truckee basin is a closed hydrologic system; all of its water is lost to evaporation, irrigation, or infiltration.

Approximately 200,000 people live in the Truckee basin, which includes the urban areas of Reno and Sparks and several smaller agricultural communities. The major crops are alfalfa, cantaloupe, onions, and garlic.

The Nevada Division of Environmental Protection (NDEP) has designated beneficial uses for the Truckee from the state line to Pyramid Lake. These uses include irrigation, livestock watering, water contact recreation, non-water contact recreation, industrial supply, municipal or domestic supply, wildlife propagation, and propagation of aquatic life.

A drought in the Truckee basin since 1987 has caused extended periods of low flow. High nitrogen and phosphorus loads, combined with the lack of a major flushing event, have caused aquatic plants to proliferate, resulting in abundant accumulations of benthic plants and detritus.

Water flow in the Truckee River is highly regulated, and the demand for water often exceeds the supply. Since 1915, the majority of river flow during non-runoff periods has been withdrawn from the river at Derby Dam and conveyed down the Truckee Canal to irrigate farmland in Fernley and Fallon, located in the Carson River basin. Regulated flows during non-runoff periods in the river section between Reno and the Derby Dam are typically about 350 cubic feet per second (cfs). About 35 cfs remains in the river below Derby (Brock et al., 1992).

Dissolved solids and nutrient loads enter the Truckee River from numerous sources, including agricultural land drainage, urban runoff, groundwater discharge, and treated wastewater effluent. The Truckee Meadows Wastewater Reclamation Facility (TMWRF), located in Reno, is the major point source in the basin, discharging, on average, 28 million gallons per day (mgd) into the river. The facility was upgraded to provide tertiary treatment in the late 1980s. Other, less significant point sources include a plastics manufacturer, an aquaculture operation, water treatment plants (clarifier drainage, screen wash water, excess intake water), stormwater outfalls, and cooling water returns.

Programmatic Issues

Water quantity and quality play a major role in the management of the Truckee River. Drought conditions magnify the effects of pollutant loadings from point sources, stormwater, and irrigation return flows. Jurisdictional issues, such as water rights and inter-basin water transfer, affect the preservation of wetlands, the protection of endangered species, and have required the involvement of federal, state, and local agencies (see box).

In 1989, NDEP developed the first version of the *Truckee River Strategy* to coordinate multi-agency management activities and serve as a framework for progress evaluation. The strategy summarizes measures for managing point and nonpoint source nutrient loads, and presents a schedule for implementing these measures. The goals of the strategy are as follows:

- To restore the quality of the Truckee so that water quality standards are attained and beneficial uses are supported.
- To preserve, protect, and enhance the water quality of Pyramid Lake.

Currently, the Truckee River does not support its designated uses. As a result, the river at Lockwood is listed on Nevada's 303(d) list for total nitrogen (TN), total phosphorus (TP), and total dissolved solids (TDS).

Agencies Involved in Truckee River Water Quality Programs

Pyramid Lake Paiute Tribe
Washoe County, Nevada
Nevada Division of Environmental Protection
U.S. EPA
U.S. Geological Survey
U.S. Army Corps of Engineers

ASSESSING AND CHARACTERIZING THE PROBLEM

Water quality monitoring on the Truckee is carried out primarily by two entities. The TMWRF is required to monitor the river to demonstrate pre- versus post-wastewater treatment project conditions. The Desert Research Institute (DRI) monitors the river monthly as part of Nevada's routine monitoring network (NDEP, 1993a).

Monitoring data from the past decade have indicated that high nitrogen and phosphorus loads, associated largely with TMWRF and irrigation return flows, have significantly impacted the Truckee. Figures 3 and 4 present annual average total nitrogen and total phosphorus loads for the Truckee at Lockwood, Nevada.

These elevated nutrient loads have encouraged the proliferation of aquatic plants and benthic algae. Respiration by these plants and the decay of their associated detritus decreases dissolved oxygen (DO) in the water column, resulting in violations of the DO standard. Violations of the instream DO standard have continued in spite of recent nutrient removal enhancements to the TMWRF.

Routine monitoring data collected by NDEP and the DRI indicate that DO concentrations regularly fall below the 5.0 mg/L standard, especially at locations downstream from the Derby Dam, such as Lockwood (Figure 5). Low DO has caused several fish kills, impacting populations of Lahontan cutthroat trout and cui-ui (kwee-wee) (Adele Basham, NDEP, personal communication, 1994). The cui-ui, a fish that has historically been a staple in the diet of the local Pyramid Lake Paiute Tribe, is on the national endangered species list. The Lahontan cutthroat trout, which supports a small recreational fishery, is classified as a threatened species.

DEVELOPING THE TMDLs

Modeling

As part of the *Truckee River Strategy*, NDEP, in cooperation with Washoe County, developed a tool to assess the impacts of future land use and flow scenarios on Truckee River water quality. In 1987, using the U.S. Geological Survey's Truckee River Water Quality Model (Nowlin, 1987) as a foundation, NDEP developed the Dynamic Stream Simulation and Assessment Model (DSSAM) to evaluate the potential effects of upgrading the TMWRF to advanced wastewater treatment.

DSSAM is designed for use on free-flowing waters where benthic processes are important factors in overall

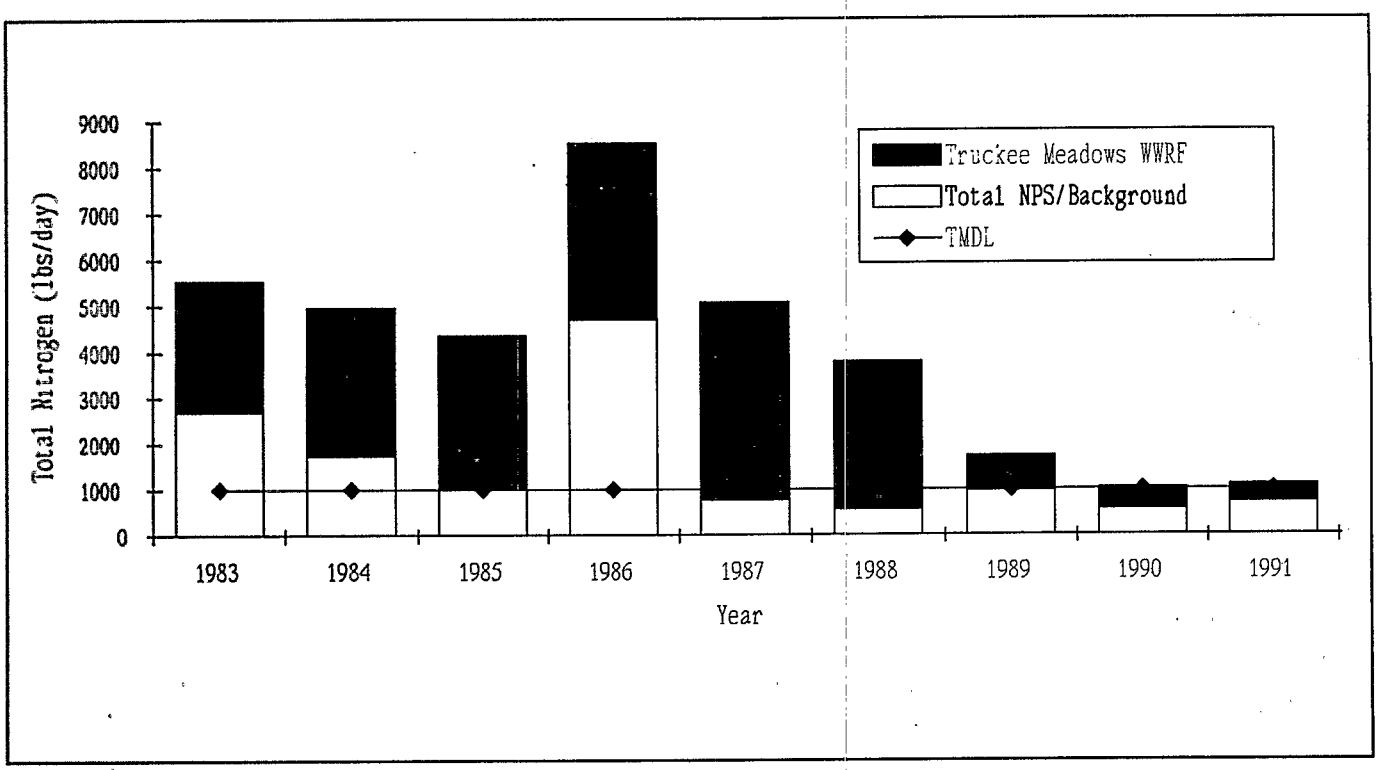

FIGURE 3. Annual average total nitrogen loads in the Truckee River from 1983 to 1991

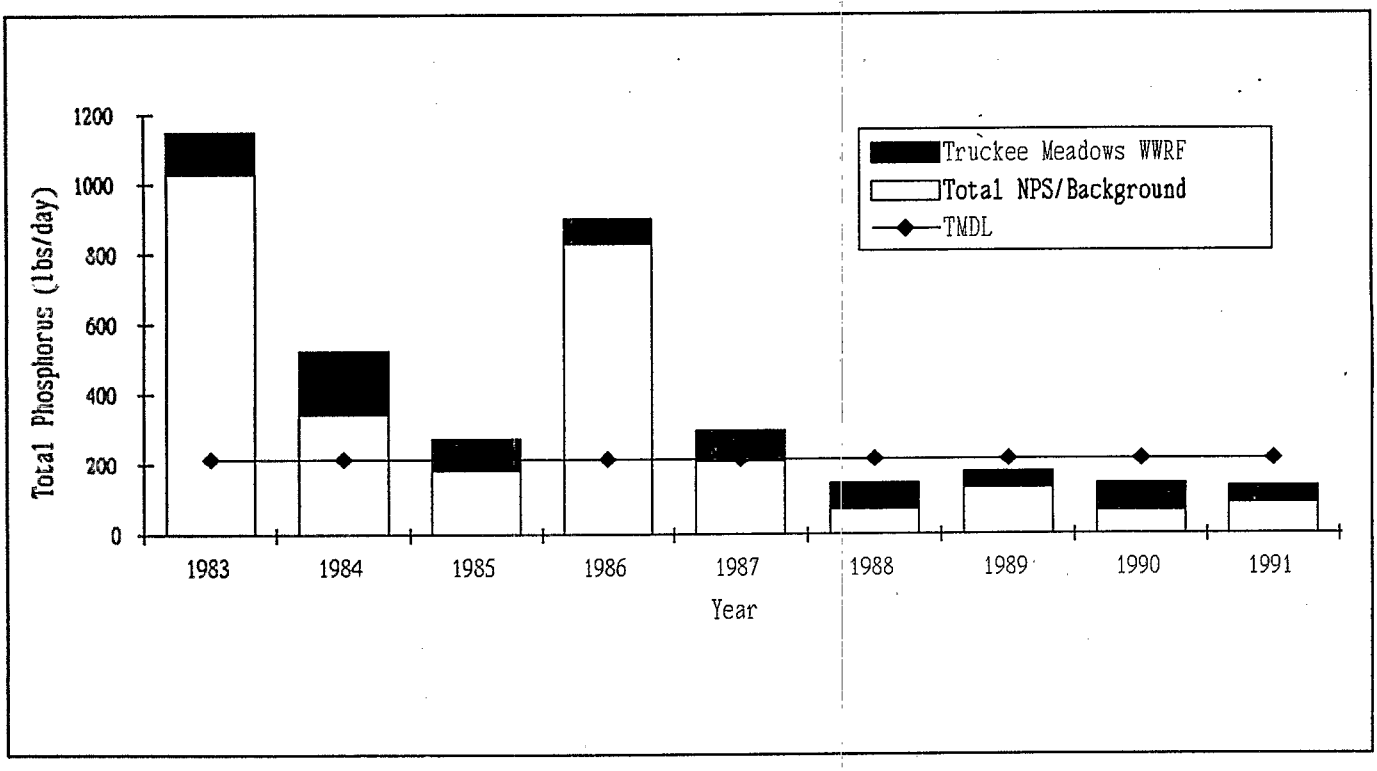

FIGURE 4. Annual average total phosphorus loads in the Truckee River from 1983 to 1991

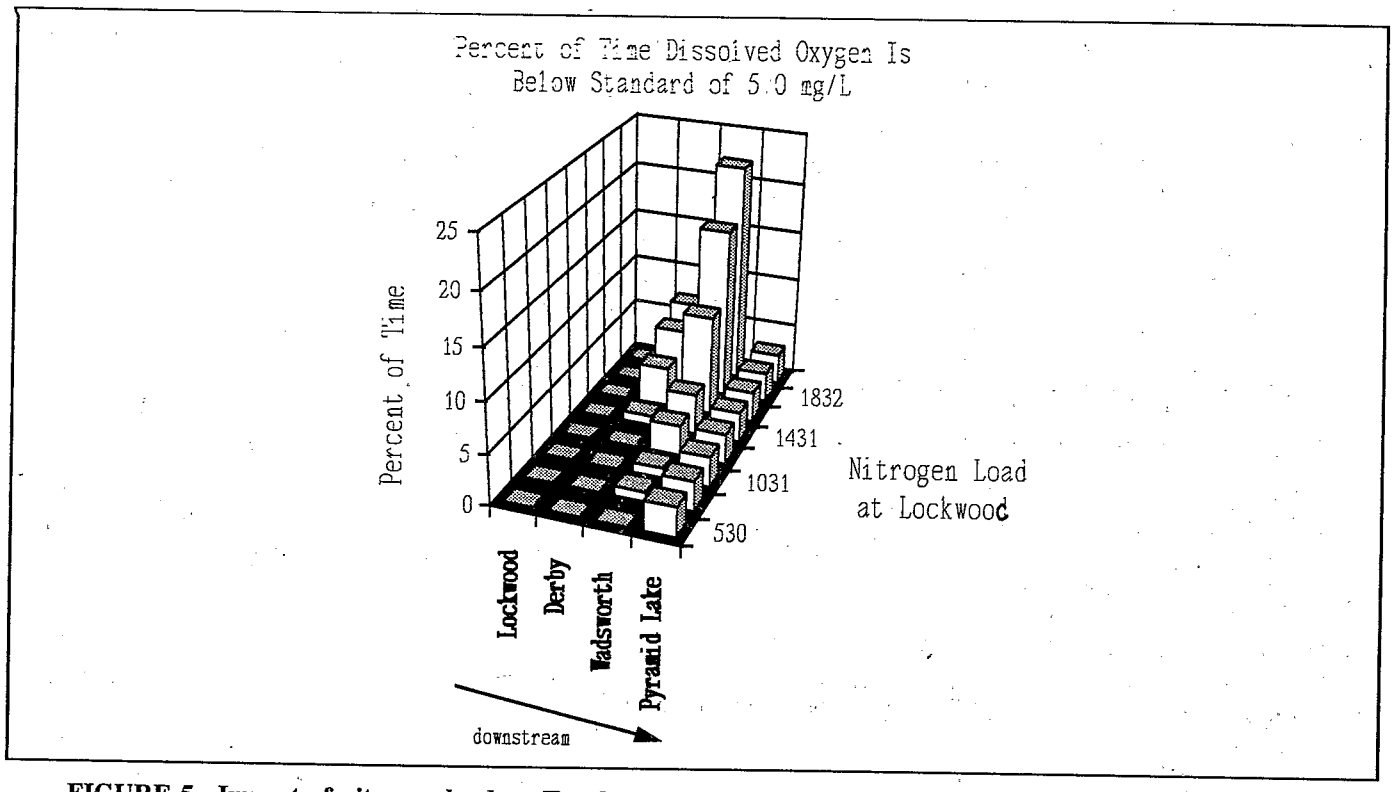

FIGURE 5. Impact of nitrogen load on Truckee River dissolved oxygen at Lockwood, June - August 1988

water quality. Key processes simulated by the model include transformations of various forms of nitrogen and phosphorus, decay of oxygen-demanding substances, and the carbonate equilibrium process that determines pH. Although the model is dynamic with respect to biological processes and boundary chemistry, it is steady-state with respect to flow. DSSAM was applied to the Truckee as a steady-state model; that is, river and tributary flows were assumed to be constant during the individual time periods of the model (Brock et. al., 1992).

Because the river's beneficial uses were not being supported under existing standards, NDEP initiated a study of the Truckee in 1990 to develop more stringent water quality-based standards to ensure support of designated uses. Although new, more stringent standards were the original goal of the modeling project, NDEP decided to use permit limitations and TMDLs in the short term to facilitate the pursuit of other means of increasing DO, such as flow augmentation.

NDEP calibrated the DSSAM model based on monitoring data from 1989, the first full year of data after advanced treatment was installed at the TMWRF. The calibration parameters included nutrient concentrations, flow, DO, pH, and various parameters associated with benthic algae productivity (e.g., nutrient uptake by benthic algae, scour at high velocities, removal of algae by invertebrates). The calibration data came from the routine monitoring programs conducted by the DRI, NDEP, and the cities of Reno and Sparks. Although the model was not formally validated, the modelers noted that previous applications of the model had shown that it behaved well.

Once calibrated, DSSAM was used to simulate water quality in the Truckee under various flow and nutrient loading scenarios. Both agricultural and municipal sources were considered. Based on the model results, NDEP evaluated the ability of existing state standards to protect beneficial uses. The outcome of this evaluation was used to determine TMDL endpoints that would result in attainment of standards (Table 1).

Total Nitrogen

Using DSSAM, NDEP determined that nitrogen is the limiting nutrient for plant growth in the river. The DSSAM model showed that, if the existing flow regime persisted, further restrictions on nitrogen loads would be needed to improve oxygen conditions in the Truckee.

The mean 30-day low flow at Lockwood was 273 cfs for the period from 1973 to 1989. DSSAM simulations determined that nitrogen loads in excess of 1000 lb/day during low flow at Lockwood result in accumulations of aquatic plants and subsequent DO depletion. Based on these results, Brock et al. (1992) recommended that the low flow nutrient limit of 1000 lb/day be maintained for all flow regimes until further studies document the effect of this loading on Pyramid Lake.

TABLE 1. TMDLs for the Truckee River at Lockwood (NDEP, 1993b)

Parameter	Total Maximum Daily Load (lb/day)	Wasteload Allocation[1] (lb/day)		Load Allocation (lb/day)
Total dissolved solids	900,528	*If flow <= 30 MGD:* *If flow 30-40 MGD:* *Permit maximum:*	90,126 flow x 360 mg/L x 8.3 120,168	<780,360
Total nitrogen	1000	500		500
Total phosphorus	214	134		80

[1] Used in the Truckee Meadows NPDES Permit.

NDEP has established the 1000 lb/day recommendation as the total nitrogen TMDL for the Truckee at Lockwood. Existing state data show that the average nonpoint source nitrogen load to the river at Lockwood is approximately 500 lb/day. Consequently, a load allocation for nonpoint and background sources was set to 500 lb/day. For the period from 1983 to 1991, the mean total nitrogen load from the TMWRF was 2,489 lb/day. The new TMWRF wasteload allocation of 500 lb/day requires reducing the load by 1,989 lb/day. For the same period, the mean total phosphorus load was 89 lb/day, which is less than the wasteload allocation of 134.

Figure 3 shows total nitrogen loading to the Truckee from 1983 through 1991. Although the 1990-91 loads are near the TMDL, they were recorded during a drought period. Given normal rainfall, and the subsequent normal flow, loads would have been in excess of the TMDL. To incorporate a margin of safety, NDEP modelers used conservative estimates on the DSSAM model parameters.

Total Dissolved Solids

Although the Truckee at Lockwood is identified on Nevada's 303(d) list for total dissolved solids (TDS), the water quality standards for TDS are being attained. The TDS TMDL is proposed in accordance with EPA's TMDL guidance, which recommends taking a proactive, pollution prevention approach to water quality management (USEPA, 1991).

The TDS TMDL was calculated as 900,528 lb/day based on simple dilution calculations using average flow and the state TDS standard of 210 mg/L. The wasteload allocation for the TMWRF varies depending on the total discharge from the facility (Table 1). Because conservative pollutants are assumed not to decay or settle, the calculated values are believed to give a reasonable upper bound for expected instream concentrations, thereby incorporating a margin of safety.

Total Phosphorus

Since phosphorus was also assumed to behave conservatively, NDEP used the same dilution calculations that were used for TDS to determine the phosphorus TMDL. The instream standard for total phosphorus is 0.05 mg/L and the TMDL was calculated as 214 lb/day at Lockwood. Existing data indicate that approximately 80 lb/day are attributable to nonpoint sources and background. The remaining 134 lb/day were set as the total phosphorus wasteload allocation for the TMWRF.

IMPLEMENTING CONTROLS

In September 1993, NDEP completed the final TMDLs for total nitrogen, total phosphorus, and total dissolved solids. The TMDLs were approved by EPA Region IX in March 1994 (David Smith, USEPA Region IX, personal communication, 1994).

The Truckee River TMDLs provide quantitative goals for the various programs being undertaken to improve Truckee water quality. Table 2 summarizes the current and planned "water quality attainment" programs for the Truckee basin.

FOLLOW-UP MONITORING

NDEP and the TMWRF are responsible for follow-up monitoring activities. NDEP will continue its long-term monitoring of the Truckee, collecting data on total phosphorus, total nitrogen, nitrate-N nitrite-N, un-ionized ammonia, DO, and flow. The TMWRF will conduct detailed grab sample monitoring for a suite of chemical constituents, plankton, and benthic invertebrates. The

TABLE 2. Current and proposed water quality attainment programs in the Truckee River basin (NDEP, 1993; Adele Basham, NDEP, personal communication, 1994)

Program or Action	Description
Irrigation modification	Agricultural operations in the Truckee River basin generally surface-irrigate with fresh water diverted from the Truckee. The tailwater runoff is often high in nitrogen, phosphorus, and suspended sediments. NDEP has recommended using sprinkler irrigation, which eliminates tailwater runoff and its associated loadings.
Clean Lakes	Using Clean Lakes grant funding from EPA, Nevada issued the Pyramid Lake Paiute Tribe a grant to study the consequences of increased nutrient loading on Pyramid Lake.
Stormwater permitting	Washoe County, the Nevada Department of Transportation, and the Cities of Reno and Sparks were issued permits to discharge to the Truckee River from stormwater outfalls. The permittees have legal authority to control pollutants in stormwater discharges, prohibit illegal discharges, require compliance, and carry out inspections.
Steamboat Creek Nonpoint Source Pollution Control Project	Reno and the Washoe County Department of Comprehensive Planning will assess the feasibility of constructing alum addition facilities to remove phosphorus and suspended sediment from urban runoff and agricultural return flows. Estimated capital cost is nearly $5 million and estimated yearly operation costs are $1,368,400.
Washoe County Water Quality Education Program	A public education program by the University of Nevada (Reno Campus) Cooperative Extension, aimed at reducing nonpoint source pollution loads, targeted all residences and agricultural activities within the basin.
Herman Ditch Project	The Herman Ditch Project will evaluate the water quality impacts of agricultural activities, which are the primary nonpoint pollution source in the basin, and will develop pollution prevention best management practices (BMPs) for agriculture.
Flow augmentation	Model runs have indicated that Truckee River water quality could be greatly improved by purchasing water rights and augmenting the flow of the lower river during critical periods.
Wetlands treatment systems	Washoe County and the local Airport Authority are investigating the use of constructed wetlands to reduce nutrient and sediment loads to the Truckee and its tributaries.
Stream protection	Since animal wastes are a significant source of pollutant to Steamboat Creek, NDEP is investigating the placement of 17 miles of fencing to keep grazing animals out of the riparian corridor.

facility also conducts bioassays and operates a continuous DO sampler. Data collected through these efforts will indicate whether the TMDLs are successful in attaining water quality standards in the Truckee River and Pyramid Lake. If needed, these data might be used to refine the TMDLs if water quality standards within a waterbody are not being attained.

REFERENCES

Brock, J.T., C.L. Caupp, and H.M. Runke. 1992. *Evaluation of water quality using DSSAM III under various conditions of nutrient loadings from municipal wastewater and agricultural sources: Truckee River, Nevada. Executive summary.* Bureau of Water Quality Planning, Nevada Division of Environmental Protection, Carson City, Nevada.

NDEP. 1993a. *Truckee River strategy.* Nevada Division of Environmental Protection, Carson City, Nevada.

NDEP. 1993b. *Truckee River final total maximum daily loads and waste load allocations.* Nevada Division of Environmental Protection, Carson City, Nevada.

Nowlin, J.O. 1987. *Modeling nutrient and dissolved oxygen transport in the Truckee River and Canal downstream from Reno, Nevada.* U.S. Geological Survey Water Resources Investigations Report 87-4037. Carson City, Nevada.

USEPA. 1989. *Regionalization as a tool for managing environmental resources.* EPA 600/3-89-060. U.S. Environmental Protection Agency, Washington, DC.

USEPA. 1991. *Guidance for water quality-based decisions: The TMDL process.* EPA 440/4-91-001. U.S. Environmental Protection Agency, Office of Water, Washington, DC.

This case study was prepared by Research Triangle Institute, Research Triangle Park, NC, in conjunction with USEPA, Office of Wetlands, Oceans, and Watersheds, Watershed Branch. To obtain copies, contact your EPA Regional 303(d)/TMDL Coordinator.